Rice University
Civil and Environmental Engineering

CEVE 518 –CONTAMINANT HYDROGEOLOGY

SPRING 2018 Syllabus

Course objectives

1. Develop an understanding of the basic equations of groundwater flow and contaminant transport, and how to apply them to real-life problems.
2. Understand how physical, chemical, and biological processes that affect chemicals as they are transported through the environment.
3. Understand the limitations in data and our ability to accurately predict groundwater flow and contaminant transport.
4. Learn how to assimilate diverse and sometimes sparse information to draw conclusions about contamination issues through homework problems and a class project.
5. Learn the potential of groundwater and vadose zone modeling software.

Textbooks

Required:

Charbeneau, R.J., *Groundwater Hydraulics and Pollutant Transport*, Waveland Pr Inc, 2006.

Highly Recommended:

Bedient, P.B., H.S. Rifai, and C.J. Newell, *Ground Water Contamination; Transport and Remediation, 2nd Ed.*, Prentice Hall, Upper Saddle River, NJ, 1999.

Other useful references:

Anderson, Mary P. and William W. Woessner, Applied Groundwater Modeling; Simulation of Flow and Advective Transport, Academic Press, Elsevier, San Diego, 2002.

Bear, Jacob, Dynamics of Fluids in Porous Media, Dover Publications, New York, 1972.

Bear, Jacob, Hydraulics of Groundwater, Mcgraw-Hill, 1979.

Crank, J., The Mathematics of Diffusion, 2nd Ed., Oxford University Press, Oxford, Great Britain, 1975.

Domenico, P.A. and F.W. Schwartz, *Physical and Chemical Hydrogeology, 2nd Ed.*, John Wiley and Sons, 1997.

Fetter, C.W., Applied Hydrogeology, 4th Ed., Prentice Hall, Upper Saddle River, NJ, 2001.

Fetter, C.W., *Contaminant Hydrogeology, 2nd Ed.*, Waveland Press Inc, 2008.

Freeze, R.A. and J.A. Cherry, *Groundwater*, Prentice Hall, 1979.

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Pankow, J. F. and J. A. Cherry, 1996, Dense Chlorinated Solvents and Other DNAPLs in Groundwater, Waterloo Press, Portland, Oregon, 1996.

Spitz, Karlheinz and Joanna Moreno, A Practical Guide to Groundwater and Solute Transport Modeling, John Wiley and Sons, New York, 1996.

Strack, Otto D.L., Groundwater Mechanics, Strack Consulting Inc., North Oaks, MN, 1999.

Todd, D.K. and L.W. Mays, *Groundwater Hydrogeology*, 3rd Ed., John Wiley and Sons, 2004.

Zheng, Chunmiao and Gordon D. Bennett, Applied Contaminant Transport Modeling, 2nd Ed., John Wiley and Sons, New York, 2002.

Grading

Tests (2)	50%
Homework	25%
Group Project Presentation	5%
Group Project Report	20%

Attendance at all lectures is expected and missing classes without prior notification will negatively impact your grade.

Tests

Two tests will be given:

- A closed-book in-class test on or around February 20. You will be provided with a hand-out of important equations.
- A take-home, open-book, open-notes test distributed on or around April 5 and will be due one week later, on or around April 12.

Selected tests from current and previous semesters and solutions will be posted on Canvas. Because the group project will be a significant effort, there will be no final exam.

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Homework

Homework assignments will require significant effort on your part. They are designed to give you practice at applying the course material in a way that you probably will in your professional life after college. Homework assignments will generally be due 1 to 2 weeks after distribution. Assignments and solutions will be posted on Canvas. Grades on late homework assignments will be reduced by 10 percent of the possible homework grade for each day or part of day that they are late. Extensions can be given *with prior arrangement*.

Project

Project – Groundwater model exercise (group report). Project includes:

- Development of a conceptual model.
- Estimate of hydraulic parameters from data.
- Simulation of contaminant transport in the vadose zone.
- Construction and calibration of a saturated zone flow model.
- Construction and calibration of a mass transport model.
- Design of groundwater remediation system.
- Presentations (tentatively scheduled for last day of class: April 19).
- Report (also tentatively due last day of class: April 19).

Instructor and Office Hours

Phillip C. de Blanc, Ph.D., P.E.
107 Mech Lab
Mobile: 281-635-6069 (Emergencies only please!)
Email: pcd1@rice.edu

Office hours by appointment.

I check email regularly, and you are encouraged to communicate by email whenever possible. I will usually respond within a few hours, but (almost) never more than 24 hours later (except on holidays and weekends).

CEVE 518 Course Outline and Lecture Schedule, Spring 2018

Day	Date	Week	Subject	Reading Assignment	Other Notes Assign/Submit
Tue	9-Jan	1	***Overview of GW hydrology*** - Basic concepts - Issues and course preview - Obtaining model software		
Thu	11-Jan	1	***Hydrologic cycle and aquifers*** - Types of aquifers - Soil horizons - Aquifer and soil properties	Bedient: Chapter 1; 15 - 23 Charb: Chapter 1	
Tue	16-Jan	2	***Darcy's Law and hydraulic conductivity*** - Darcy's Law - Permeability - Hydraulic Conductivity - Layered media - Anisotropy - Darcy's Law range of applicability (Re)	Bedient: 23 - 30 Charb: 18 - 37 Charb: 44 - 48	Hwk 1 Issued.
Thu	18-Jan	2	***Steady-state groundwater flow in 1-D*** - Transmissivity - Regional flow per unit width of aquifer - Head distribution in confined aquifers - Head distribution in unconfined aquifers - Unconfined aquifers with recharge - Head distribution in leaky aquifers	Bedient: 34 - 41; 49 - 50 Charb: 48 - 67	
Tue	23-Jan	3	***Well hydraulics and steady flow*** - Steady flow to a well; confined aquifer - Theim equation - Steady flow to a well; unconfined aquifer - Image wells	Bedient: 50 - 58 Charb: 91 - 105	Hwk 1 due.
Thu	25-Jan	3	***Numerical flow modeling*** - Finite differences - Introduction to MODFLOW	Bedient: 335 - 370 Charb: 428 - 430	Hwk 2 issued.
Tue	30-Jan	4	***Well hydraulics and transient flow*** - Theis equation - Jacob approximation - Radius of influence - Superposition	Bedient: 58 - 60 Charb: 105 - 115	
Thu	1-Feb	4	***Aquifer testing and transient flow*** - Slug Test - Specific capacity test - Pumping test, single well - Pumping test, two wells - Recovery test	Bedient: 60 - 70 Charb: 115 - 125; 140 - 150 Charb: 125 - 138; 150 - 154	Hwk 2 due. Hwk 3 issued.
Tue	6-Feb	5	***Transient flow problems cont.***		
Thu	8-Feb	5	***Spring Recess - No class***	Bedient: 71 - 73 Charb: 154 - 158	
Tue	13-Feb	6	***Vadose zone hydraulics*** - Capillary pressure - Matric potential - Soil moisture characteristic curves - Saturation/hydraulic conductivity relationships - Richard's equation - Simplifying assumptions	Bedient: 289 - 298; 303 - 315 Charb: 179 - 204	Hwk 3 due. Hwk 4 issued.
Thu	15-Feb	6	**Field Exercise** - Water level measurement - Slug test - Specific capacity test **END OF EXAM 1 MATERIAL**		

CEVE 518 Course Outline and Lecture Schedule, Spring 2018

Day	Date	Week	Subject	Reading Assignment	Other Notes Assign/Submit
Tue	20-Feb	7	***Exam 1 (in class)***		
Thu	22-Feb	7	***Groundwater contamination*** - Sources - LNAPL/DNAPL - Vapor migration	Bedient: 75 - 98; 108 - 110 Charb: 247 - 263	Hwk 4 due.
Tue	27-Feb	8	***Equilibrium partitioning*** - Air/water - Solid/water (adsorption) - NAPL/water	Bedient: 203 - 215 Charb: 263 - 277; 289 - 291	Hwk 5 issued.
Thu	1-Mar	8	***Advective transport*** - Potential theory introduction - Groundwater capture - Flow nets	Bedient: 41 - 45 Charb: 293 - 300; 303 - 306; 310 - 314	
Tue	6-Mar	9	***Diffusive transport***	Bedient: 162 - 165 Charb: Chapter 7	Hwk 5 due.
Thu	8-Mar	9	***Diffusion (cont.)***		Hwk 6 issued.
Tue	13-Mar	10	***Spring Break - No Class***		
Thu	15-Mar	10	***Spring Break - No Class***		
Tue	20-Mar	11	***Advection-dispersion equation*** - Formulation - Physical nature of dispersion - Estimating dispersivity - Boundary conditions - 1-D solutions	Bedient: 170 - 184 Charb: 365 - 366; 373 - 378 384 - 390	
Thu	22-Mar	11	***ADR equation solutions and applications*** - 2-D/3-D solutions	Charb: 366 - 373; 396; 399 - 417	Hwk 6 due.
Tue	27-Mar	12	***Reactions***		Hwk 7 issued.
Thu	29-Mar	12	***Groundwater Remediation*** - Active remediation - Passive remediation - Natural attenuation **END OF EXAM 2 MATERIAL**	Bedient: 479 - 497	
Tue	3-Apr	13	***Mass balances for contaminant transport*** - Mass balance basics - Linking models		Hwk 7 due.
Thu	5-Apr	13	***Case study***		**Exam 2 Issued**
Tue	10-Apr	14	***Mass transport modeling*** - MT3D/RT3D - Project setup	Bedient: 371 - 384	
Thu	12-Apr	14	***Project Work Session***		**Exam 2 Due**
Tue	17-Apr	15	***Project Work Session***		
Thu	19-Apr	15	***Project Presentations*** ***Last day of class***		
Mon	1-May		***Projects Due***		
Wed	2-May		***Last day of finals***		
Sun	7-May		***Grades due for graduating seniors***		
Thu	11-May		***Grades due for all others***		